Visualization 2004 and Beyond

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Visualization has matured during the past 15 years. Since the initial NSF Workshop report, it has grown into a field that supports an active annual conference, a high-quality IEEE Transactions, and a growing number of researchers addressing problems in many different scientific domains. In some ways, the field of visualization has changed,
i.e. no longer are $100k+ workstations required for large-scale visualization, but in many other ways that field has not changed, though it has evolved. The overall goal remains providing visual representations to better comprehend data. The algorithms have matured but the overall mission of visualization remains. There are multiple issues facing visualization as a fundamental research field. Some of these can be captured with the following questions:

1. What are the best representations for conveying information?
2. How can quantitative analysis be coupled with visualization techniques?
3. What data mining methodologies are tied to such analysis?
4. How can visualization methods capture the error and uncertainty in both the data and the process of visualization and analysis?

The field has sought visual metaphors for representing underlying data. Using physical models as an example has led to many flow-based techniques that mimic physical processes. However, the challenge for the future is how to better represent data in ways that increases understanding. Such metaphors typically require expertise in the field which the visualization is attempting to assist. Such coupling of scientific domain with the visualization process is required and necessary for new and better representational methods to evolve.

Many visualization techniques do not provide quantitative analysis but merely a visual form. Such analysis is not only required but can greatly add to the comprehension of the data for which visualization is attempting to provide a better understanding. Interactive methods are critical for the exploration and analysis of large datasets. Coupling these methods with quantitative abilities will lead to better analysis capabilities. As time marches on, the size of data sets continue to increase. This is due to both technological advances as well as computational advances that have led to more complex computational models. The ability to interact and analyze such massive data sets remains an unsolved problem. Current data mining techniques have only scratched the surface of the possible solutions. Many such techniques are domain specific and whether such methods can be abstracted to cross disciplines remains to be seen.

Lastly, visualization methods have largely ignored the effects of errors and uncertainly in their presentation of data. Such oversight can lead to misrepresentation of the data rather than better comprehension of the underlying science. The ability to understand the certainty of a particular analysis or the accumulation of errors based on methods applied would strengthen the analytical aspects of visualization. Similarly, strength of uncertainty in spatial location, computational methods that produced the data, a representation of noise in the data, would assist in analysis.

Visualization is not a solved problem. New techniques remain to be discovered. New robust methods, which incorporate domain specific